engineering fracture mechanics

List of Contents and Author Index
Volume 35, 1990

PERGAMON PRESS

OXFORD · NEW YORK
BEIJING · FRANKFURT · SÃO PAULO · SYDNEY · TOKYO · TORONTO

engineering fracture mechanics

An International Journal

EDITOR-IN-CHIEF

PROFESSOR HAROLD LIEBOWITZ

School of Engineering and Applied Science, The George Washington University, Washington, DC 20052, U.S.A.

EDITORIAL ADVISORY BOARD

PROFESSOR S. N. ATLURI, Georgia, U.S.A.
DR. ZDENEK BILEK, Brno, Czechoslovakia
PROFESSOR BRUNO A. BOLEY, New York, U.S.A.
DR. DAVID BROEK, Ohio, U.S.A.
PROFESSOR JANNE CARLSSON, Stockholm, Sweden
PROFESSOR G. P. CHEREPANOV, Moscow, U.S.S.R.
PROFESSOR H. T. CORTEN, Illinois, U.S.A.
DR. J. R. DAVIDSON, Virginia, U.S.A.
DR. THEODOR GAYMANN, Munich, Federal Republic of Germany
DR. GEORGE T. HAHN, Ohio, U.S.A.
PROFESSOR GEORGE HERRMANN, California, U.S.A.
PROFESSOR D. L. JONES, Washington, D.C., U.S.A.
PROFESSOR HIROSHI KIHARA, Tokyo, Japan
DR. J. M. KRAFFT, Virginia, U.S.A.
PROFESSOR FRANK A. McCLINTOCK, Massachusetts, U.S.A.
DR. HENRI P. van LEEUWEN, Amsterdam, The Netherlands
PROFESSOR A. J. McEVILY, Connecticut, U.S.A.
DR. BRIAN MULLINS, Hants., U.K.
PROFESSOR JAROSLAV NEMEC, Prague, Czechoslovakia
DR. NICHOLAS PERRONE, Maryland, U.S.A.
DR. Y. RAJAPAKSE, Virginia, U.S.A.
DR. J. SCHIJVE, Delft, The Netherlands
DR. WALTER SCHUTZ, Ottobrunn, Federal Republic of Germany
PROFESSOR GEORGE C. SIH, Pennsylvania, U.S.A.
PROFESSOR JAN-HAN YANG, Washington, D.C., U.S.A.
PROFESSOR TAKEO YOKOBORI, Sendai City, Japan
ROBERT E. ZINKHAM, Virginia, U.S.A.

Publishing, Subscription and Advertising Offices: Pergamon Press plc, Headington Hill Hall, Oxford OX3 0BW, England; or Pergamon Press Inc., Fairview Park, Elmsford, NY 10523, U.S.A.

Annual Subscription Rates (1990)
Annual Institutional subscription rate (1990) DM 2650.00. Two year institutional rate (1990/91) DM 5035.00. Personal subscription rate for those whose library subscribes at the regular rate (1990) DM 248.00. Prices are subject to change without notice.
Published 18 Times Per Annum (Three volumes 1990). Subscription enquiries from customers in North America should be sent to Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, NY 10523, U.S.A. and for the remainder of the world to Pergamon Press plc, Headington Hill Hall, Oxford OX3 0BW, England.
Back Issues of all previously published volumes, in both hard copy and on microform are available direct from Pergamon Press offices.

Copyright © 1990 Pergamon Press plc.

It is a condition of publication that manuscripts submitted to this journal have not been published and will not be simultaneously submitted or published elsewhere. By submitting a manuscript, the authors agree that the copyright for their article is transferred to the publisher if and when the article is accepted for publication. However, assignment of copyright is not required from authors who work for organisations which do not permit such assignment. The copyright covers the exclusive rights to reproduce and distribute the article, including reprints, photographic reproductions, microform or any other reproductions of similar nature and translations. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means electronic, electrostatic, magnetic tape, mechanical photocopying, recording or otherwise, without permission in writing from the copyright holder.

The paper used in this publication meets the minimum requirements of American National Standard for Information Sciences—Permanence of Paper for Printed Library Materials, ANSI Z39.48-1984.

Photocopying information for users in the U.S.A. The Item-Fee code for this publication indicates that authorization to photocopy items for internal or personal use is granted by the copyright holder for libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service provided the stated fee for copying beyond that permitted by Section 107 or 108 of the United States Copyright Law is paid. The appropriate remittance of $3.00 per copy per article is paid directly to the Copyright Clearance Center Inc., 27 Congress Street, Salem, MA 01970.

Permission for other use. The copyright owner's consent does not extend to copying for general distribution, for promotion, for creating new works, or for resale. Specific written permission must be obtained from the publisher for such copying.

The Item-Fee Code for this publication is: 0013-7944/90 $3.00 + .00

The cover picture was taken by Dr. Erwin Sommer in his studies at the Ernst Mach Institute in Freiburg, Germany, in work under the direction of Dr. F. Kerkhof. Dr. Sommer is Director of Fraunhofer-Institut Fuer Werkstoffmechanik, Rosastraße, 9, 7800 Freiburg, Germany.

List of Contents

FRACTURE AND DAMAGE OF CONCRETE AND ROCK

NUMBER 1/2/3

	1	Preface
S. P. Shah	3	Experimental methods for determining fracture process zone and fracture parameters
J. J. Du, A. S. Kobayashi and **N. M. Hawkins**	15	An experimental–numerical analysis of fracture process zone in concrete fracture specimens
Ph. Regnault and **E. Brühwiler**	29	Holographic interferometry for the determination of fracture process zone in concrete
V. C. Li and **J. Huang**	39	Relation of concrete fracture toughness to its internal structure
V. E. Saouma, C. C. Barton and **N. A. Gamaleldin**	47	Fractal characterization of fracture surfaces in concrete
R. Ballarini	55	A semi-empirical analysis of micro-cracking in concrete
Liu Guang Ting and **Zhou Rui Zhong**	67	The strength of a finite body with multiple cracks
P. Rossi	79	Coupling between the cracking process and viscous phenomena in concrete
J. Planas and **M. Elices**	87	Fracture criteria for concrete: mathematical approximations and experimental validation
W. Brameshuber and **H. K. Hilsdorf**	95	Influence of ligament length and stress state on fracture energy of concrete
F. H. Wittmann, H. Mihashi and **N. Nomura**	107	Size effect on fracture energy of concrete
E. Brühwiler and **F. H. Wittmann**	117	The wedge splitting test, a new method of performing stable fracture mechanics tests
Minh Phong Luong	127	Tensile and shear strengths of concrete and rock
S. E. Swartz and **N. M. Taha**	137	Mixed mode crack propagation and fracture in concrete
E. Ballatore, A. Carpinteri, G. Ferrara and **G. Melchiorri**	145	Mixed mode fracture energy of concrete
P. Bocca, A. Carpinteri and **S. Valente**	159	Size effects in the mixed mode crack propagation: softening and snap-back analysis
B. Barr and **M. Derradj**	171	Numerical study of a shear (mode II) type test specimen geometry
T. G. Hughes, A. Asghari, N. K. Abbas and **B. I. G. Barr**	181	Fracture behaviour of concrete and FRC in tension
L. Biolzi	187	Mixed mode fracture in concrete beams
U. Ohlsson, P. A. Daerga and **L. Elfgren**	195	Fracture energy and fatigue strength of unreinforced concrete beams at normal and low temperatures
B. L. Karihaloo and **D. Fu**	205	An anisotropic damage model for plain concrete

R. S. Crouch and **J. G. M. Wood**	211	Damage evolution in AAR affected concretes
S. Oller, E. Oñate, J. Oliver and **J. Lubliner**	219	Finite element nonlinear analysis of concrete structures using a "plastic-damage model"
A. Hillerborg	233	Fracture mechanics concepts applied to moment capacity and rotational capacity of reinforced concrete beams
P. Bocca and **A. Carpinteri**	241	Snap-back fracture instability in rock specimens: experimental detection through a negative impulse
L. J. Malvar and **M. E. Fourney**	251	A three dimensional application of the smeared crack approach
W. S. Yin, E. C. M. Su, M. A. Mansur and **T. T. C. Hsu**	261	Fiber-reinforced concrete under biaxial compression
D. Bruno, R. S. Olivito and **G. Spadea**	269	Fracture in reinforced concrete beams under repeated loads
H. Yashiro, Y. Tanaka, M. Nagano and **Y. Ro**	277	Study on shear failure mechanisms of reinforced concrete short columns
Minh Phong Luong	291	Infrared thermovision of damage processes in concrete and rock
P. Rossi and **F. Le Maou**	303	Device for the detection and location of cracks in concrete using fibre optics
Miau-Bin Su	313	Fracture monitoring within concrete structure by time domain reflectometry
M. Curbach and **J. Eibl**	321	Crack velocity in concrete
Byung Hwan Oh	327	Fracture behavior of concrete under high rates of loading
B. Barr, A. Bouamrata and **A. Baghli**	333	Impact strength of FRC materials
G. Dinic and **S. H. Perry**	343	Shear plug formation in concrete slabs subjected to hard impact
F. Ouchterlony	351	Fracture toughness testing of rock with core based specimens
K. H. R. Moelle, G. Li and **J. A. Lewis**	367	On fatigue crack development in some anisotropic sedimentary rocks
A. T. Spathis	377	Evidence of rock microstructure from seismic wave propagation
R. Ballarini, A. Parulekar and **M. E. Plesha**	385	Finite element modeling of discontinuities with dilatancy and surface degradation
C. C. Baniotopoulos and **P. D. Panagiotopoulos**	399	A hemivariational inequality approach to the rock interface problem
J. F. Cardenas-Garcia	409	Rayleigh-wave induced crack extension
A. Rustan	425	The importance of using joints to achieve scaled fragmentation in magnetite concrete used for sublevel caving blast models
S. Bhandari and **R. Badal**	439	Post-blast studies of jointed rocks
D. P. Blair	447	Seismic pulse assessment of cracked and jointed rock
H. Habenicht	457	Failure constellations in and around underground openings

A. Di Tommaso, F. Cianfrone and G. Pascale — 473 — Detection of internal fissures on rock structural elements of historical buildings

J. Majer and G. Niederwanger — 493 — Observations during stabilization of old bell towers damaged by cracks

SPECIAL SEMINAR ON LARGE CONCRETE DAM STRUCTURES

O.-J. Rescher — 503 — Importance of cracking in concrete dams

M. Fanelli and G. Giuseppetti — 525 — Advanced dam analysis

R. Widmann — 531 — Fracture mechanics and its limits of application in the field of dam construction

H. N. Linsbauer — 541 — Application of the methods on fracture mechanics for the analysis of cracking in concrete dams

A. R. Ingraffea — 553 — Case studies of simulation of fracture in concrete dams

E. Brühwiler and F. H. Wittmann — 565 — Failure of dam concrete subjected to seismic loading conditions

M. Cervera, J. Oliver, E. Herrero and E. Oñate — 573 — A computational model for progressive cracking in large dams due to the swelling of concrete

M. L. Ayari and V. E. Saouma — 587 — A fracture mechanics based seismic analysis of concrete gravity dams using discrete cracks

E. Carabelli, P. Federici, F. Graziano, E. Rondena and A. Zaninetti — 599 — Location of AE sources in the rock foundation of the Passante Dam

607 — Abstracts of papers not included in the Proceedings of the International Conference volume. (To be published in the follow-up issue of *Engineering Fracture Mechanics*)

NUMBER 4/5

J. G. M. van Mier and M. B. Nooru-Mohamed — 617 — Geometrical and structural aspects of concrete fracture

J. Mazars, Y. Berthaud and S. Ramtani — 629 — The unilateral behaviour of damaged concrete

B. L. Karihaloo and P. Nallathambi — 637 — Effective crack model for the determination of fracture toughness (K_{Ic}^{e}) of concrete

Xu Xiao-He and Zhu Yi — 647 — Determination for the critical damage factor of a perfect brittle rock

P. G. Gambarova and G. Valente — 651 — Smeared crack analysis for fracture and aggregate interlock in concrete

C. Bosco, A. Carpinteri and P. G. Debernardi — 665 — Fracture of reinforced concrete: scale effects and snap-back instability

Yin Shuangzeng and Zhai Qiyu — 679 — A method in determination of the size effectiveness of fracture energy in concrete

Xu Jishan and He Xixi — 687 — Size effect on the strength of a concrete member

N. Bićanić and **Pankaj**	697	Some computational aspects of tensile strain localization modelling in concrete
B. A. Radovani	709	Grain size of adopted aggregate influence on strain-softening of concrete
Yin Shuang-Zen and **Zhai Qiyu**	719	An approach to determine concrete-failure softening curves
Zhou Rul-Zhong and **Liu Guang-Ting**	731	The synthetic deformation modulus and the synthetic Poisson's ratio of multiple-crack bodies
Li Zhangming	739	A new approach to rock failure: criterion of failure in plastical strain space
C. M. Sayers	743	Inversion of ultrasonic wave velocity measurements to obtain the microcrack orientation distribution function in rocks
P. Rossi, J. L. Robert, **J. P. Gervais** and **D. Bruhat**	751	The use of acoustic emission in fracture mechanics applied to concrete
W. H. K. Gerber and **E. Magyari**	765	Damage of concrete at anchor fastenings
H. Schorn, U. Rode and **T. Berger-Böcker**	771	Detection of microcrack accumulation in tensile loaded specimen
P. Stroeven	775	Some observations on microcracking in concrete subjected to various loading regimes
Tang Chunan and **Xu Xiaohe**	783	A new method for measuring dynamic fracture toughness of rock
S. Cangiano and **G. Tognon**	793	The ductile/brittle transition in concrete beams in relation to the servocontrol system of the testing machine
Tang Chunan and **Xu Xiaohe**	801	Stiffness machine characteristics and its application in an earthquake model
B. Foure, N. Ghabrial and **Y. Hanna**	807	Cracking and failure of concrete subjected to compression and torsion
D. A. Hordijk and **H. W. Reinhardt**	819	Fracture of concrete in uniaxial tensile experiments as influenced by curing conditions
P. Maturana, J. Planas and **M. Elices**	827	Evolution of fracture behaviour of saturated concrete in the low temperature range
Kou Shaoquan, **Ye Dongying** and **Ding Yansheng**	835	A constitutive model for structured coal based on fracture and damage mechanics
M. Hassanzadeh	845	Determination of fracture zone properties in mixed mode I and II
H. Hakami and **O. Stephansson**	855	Shear fracture energy of Stripa granite—results of controlled triaxial testing

U. Hunsche and **H. Albrecht**	867	Results of true triaxial strength tests on rock salt
G. Tokar	879	Experimental analysis of the elasto-plastic zone surrounding a borehole in a specimen of rock-like material under multiaxial pressure
B. Mohanty	889	Explosion generated fractures in rock and rock-like materials
C. Scavia	899	Fracture mechanics approach to stability analysis of rock slopes
L. Ferrer, A. Olivares and **O. Hernandez**	911	Optimization of plugs for the diversion tunnels of dams

NUMBER 6

Wang Tzu-Chiang	929	Asymptotic fields near the crack tip in elastic–perfectly plastic crystals
H. A. Richard and **M. Kuna**	949	Theoretical and experimental study of superimposed fracture modes I, II and III
M. Isida, T. Yoshida and **H. Noguchi**	961	Tension of a finite-thickness plate with a pair of semi-elliptical surface cracks
A. N. Palazotto and **J. G. Mercer**	967	A finite element comparison between short and long cracks within a plastic zone due to a notch
T. Fett, C. Mattheck and **D. Munz**	987	Averaged stress intensity factors for embedded elliptical cracks
X. Chen, T. Foecke, M. Lii, Y. Katz and **W. W. Gerberich**	997	The role of stress state on hydrogen cracking in Fe–Si single crystals
D. Shaw and **Y. H. Huang**	1019	Buckling behavior of a central cracked thin plate under tension
Li Changchun, Li Xiping and **Li Guangxia**	1029	Crack tip plastic damage field and near field damage criterion
X. S. Zhang	1037	A finite rectangular sheet with a pair of edge cracks excited by a normal anti-plane shear wave
A. F. Martin	1043	A stress concentration due to edge damage in a rectangular boron-epoxy sheet
B. H. Tsao, D. Tang, D. L. Jacobson and **J. F. Morris**	1049	Fracture-resistant ultralloys for space-power applications: normal-spectral-emissivity and electron-emission studies of tungsten, rhenium, hafnium-carbide alloys at elevated temperatures
S. Valliappan, V. Murti and **Zhang Wohua**	1061	Finite element analysis of anisotropic damage mechanics problems

Z. D. Jiang, A. Zeghloul, G. Bezine and **J. Petit**	1073	Stress intensity factors of parallel cracks in a finite width sheet
J. Neumeister	1081	Creep and rupture behaviour in fibre bundles
S. J. Chu and **C. S. Hong**	1093	Application of the J_k integral to mixed mode crack problems for anisotropic composite laminates
F. Z. Li and **J. Pan**	1105	Plane-stress crack-tip fields for pressure-sensitive dilatant materials
		Discussion
N. A. B. Yehia	1117	"LEFM brittle and ductile fractures as described by the T-criterion" by N. P. Andrianopoulos and P. S. Theocaris
		Technical Note
T. W. Webb, E. E. Gdoutos and **E. C. Aifantis**	1121	A preliminary report on 3D effects on caustics
	1125	Corrigendum
	I	Software Survey Section